REMARKS

Claims 1-17 are pending in the present application.

Specification

The disclosure has been objected to in view of the informalities listed on page 2 of the current Office Action dated August 12, 2008.

However, the specification has been previously corrected on page 1, line 10 and page 9, line 24 in the Amendment dated July 13, 2007. The Examiner is thus respectfully requested to withdraw this objection.

Claim Rejections-35 U.S.C. 103

Claims 1-3 and 5-17 have been rejected under 35 U.S.C. 103 as being unpatentable over the Okamoto reference (U.S. Patent No. 5,298,093) in view of SU 1148893 (abstract), and the Corwin reference (U.S. Patent No. 4,735,771) or WO 01/57280. This rejection is respectfully traversed for the following reasons.

The present invention describes the intermetallic phases such as sigma and khi phases in the specification as follows (refer to page 1, line 24 – page 2, line 8) (emphasis added):

> " However, as compared with commercial **PREW 38-level duplex stainless steel** such as SAF 2205, the **PREW 46-level high-grade duplex stainless steel** contains <u>a large amount of Cr, Mo and W which are major</u>

elements of sigma and khi phases deteriorating mechanical properties and corrosion resistance, and thus easily forms precipitation phases thereof during the production or application. Actually, embrittlement by the precipitation phases has been observed in cooling after continuous casting of duplex stainless steel, slow cooling after hot rolling, slow cooling of a heat affected zone after welding, and slow cooling of an ingot center unit after casting. In addition, Mo for improving local corrosion and SCC resistances among the added alloying elements is a high-priced element facilitating formation of sigma phases and 475°C brittleness, and thus restrictively used. **Sigma phase is a very brittle intermetallic compound formed from temperature of 650°C to 1000°C. More than 1 vol.% of sigma phase can remarkably reduce impact toughness and corrosion resistance of duplex stainless steel**. "

Also, the present invention defines a pitting resistance equivalent (PREW) by the following formula as set forth on page 14, line 21 of the present application:

PREW = wt%Cr + 3.3(wt%Mo + 0.5wt%W) + **30**wt%N.

Okamoto on the other hand defines a pitting resistance equivalent (PREW) by the following formula as indicated in the Abstract thereof:

PREW* = wt%Cr + 3.3(wt%Mo + 0.5wt%W) + **16**wt%N.

Enclosed herewith is a Table including PREW* (= PREW - **16**wt%N) (hereinafter, PREW* means Okamoto-type pitting resistance equivalent) which has been extracted and conversed in part from Tables 1 and 2 of the present application.

From the above, it should be understood that the contents of Cr, Mo, W and N are very critical for improving pitting resistance of the duplex stainless steel, but that Cr, Mo and W are major elements of the intermetallic phases such as sigma and khi phases.

In this regard, the present invention is directed to actively suppressing the intermetallic phases by adding additional elements together with increasing PREW values, i.e., increasing Cr, Mo, W and N. The results thereof will be concisely explained in the latter stages of this response.

A question that arises and that will now be addressed is whether the Okamoto reference discloses a duplex stainless steel suppressing formation of sigma and khi phases.

The Examiner's main position that the present invention is obvious in view of the cited prior art references including the Okamoto reference is based on the Examiner's assertion that "Okamoto discloses the features ...... suppressing formation of sigma and khi phases (col. 2. Lines 1-32)" (See page 3, lines 10 - 11 and the bottom of page 4 of the outstanding Office Action).

However, the portion in the Okamoto reference cited and specifically relied upon by the Examiner only discloses that 1) in a duplex stainless steel having **increased** Cr and Mo contents, intermetallic compounds (σ- and similar phases) are precipitated, **resulting in a deterioration** in not only corrosion resistance but also in mechanical properties such as toughness and ductility in heat affected zones; and 2) the Okamoto

reference provides a duplex stainless steel which is **less susceptible** to precipitation of intermetallic compounds of σ- and similar phases.

Moreover, as acknowledged on the record by the Examiner in the lower portion of page 6 in the Response to Arguments section of the outstanding Office Action, "**delaying** a precipitation speed of ... sigma and khi phases" **is not the same** (or is totally different) as **suppressing** formation of intermetallic sigma and khi phases as in the present invention. Applicants emphasize that "**less susceptible** to precipitation of intermetallic compounds of σ- and similar phases" in the Okamoto reference is totally different from **suppressing** formation of intermetallic sigma and khi phases according to the present invention.

Even though the Okamoto reference provides minimal teachings to control sigma and similar phases, such teachings only reach that W is effective for improvement in corrosion resistance but, unlike Mo, causes **little acceleration** of the formation of σ- and similar phases (refer to Col. 3, line 64 – Col. 4, line 17 and Col. 6, lines 1 – 36 in the Okamoto reference). That is, the Okamoto reference only discloses that σ- and similar phases can be controlled by **decreasing** Mo and Cr but with increasing W (refer to Col. 6, lines 27 – 30 in Okamoto), because W has **little effect on acceleration** of the formation of σ- and similar phases because of its low rate of diffusion (refer to Col. 4, lines 12 – 17 in the Okamoto reference).

On the contrary, the present invention is directed to **adding** additional alloying elements such as Ba (Claim 1) and MM and/or Y (Claim 4) which have much larger

atomic diameters than the intermetallic phase formation elements such as Cr, Mo, Si and W (please note that W is still one of intermetallic phase formation elements even though W delays the formation of intermetallic phase, compared to Cr, Mo and Si), in order to **actively suppress** the formation of the intermetallic phases, in which the alloying elements fill atomic vacancies in austenitic and ferritic phase-boundaries and crystal grains of ferritic phase, to block a diffusion path of Cr, Mo, Si and W.

With further regard to the examiner's above noted position as stated at the bottom of page 6 in the Response to Arguments section of the outstanding office Action, as noted above, Applicants agree that "delaying" is totally different from "suppressing".

Applicants also emphasize that the portion of the present application cited by the Examiner in this regard explains the role of W in the present invention. That is, it should be understood that W improves corrosion resistance and mechanical properties by delaying a precipitation speed of brittle sigma and khi phases after sensitization heat-treatment or welding, but if a large amount of W is used, it **still facilitates** formation of intermetallic compounds.

Again, Applicants emphasize that the idea of the Okamoto reference was finding the role of W in delaying (or accelerating less) the formation of intermetallic phases. In contrast, the present invention concerns the realization of finding out that W still facilitates formation of intermetallic compounds if a large amount of W is added, and by finding out the roles, effects and mechanisms of additional elements such as Ba (Claim

1) and MM and/or Y (Claim 4) for actively suppressing the formation of intermetallic phases.

Beginning at the top of page 6 in the Response to Arguments section of the outstanding office Action, the Examiner apparently continues to require identification in the application for support of the claim amendments made in the Amendment dated January 22, 2008, relying on 37 C.F.R. 41.37 (c)(1)(v). However, 37 C.F.R. 41.37 (c)(1)(v) concerns formal requirements of an Appeal Brief, and is thus irrelevant and improperly relied upon by the Examiner in this instance. As stated in the Letter Responsive to Notice of Non-Compliant Amendment dated June 2, 2008, during a telephone interview on May 29, 2008, Supervisor Roy King acknowledged that the requirement is improper and would thus be withdrawn. **The Examiner is thus respectfully requested to concede that this issue is no longer outstanding.**

In a further effort to dispose of this issue, support in the present application for the amendment made to claims regarding "suppressing formation of intermetallic phases including sigma and khi phases", can be found as follows: the title of invention; page 1, lines 10 – 11 of page 1; page 2, line 10; page 5, line 7; page 6, lines 6 - 8, 14 – 15 and 22 – 23; page 7, lines 5 – 6; page 9, lines 15 – 16; page 10, lines 19 and 24 - 25; page 11, lines 7 – 8; page 16, lines 25 – 26; page 21, lines 23 – 24; lines 24 – 26; and page 35, lines 19 – 22. One of ordinary skill would readily understand that the previous claim amendments are clearly supported at least in view of the above noted portions of the present application.

Applicants now address the Examiner's position as stated on page 7, lines 5-11 in the Response to Arguments section of the outstanding Office Action as follows.

In the Okamoto reference, calcium (Ca), magnesium (Mg), boron (B) and rare earth metals (REM) such as cerium (Ce) all serve to improve the hot workability of the steel by fixing sulfur or oxygen (refer to Col. 7, lines 38 – 40 in the Okamoto reference). Such a mechanism is very well known in the related field, as shown in "Properties and Selection: Irons, Steels, and High Performance Alloys", ASM HANDBOOK, Vol. 1, 1990, submitted along with the Information Disclosure Statement dated July 13, 2007. That is, page 409 of the above document discloses as follows:

> *Rare-earth elements*, principally cerium, lanthanum, and praseodymium, can be used to provide shape control of sulfide inclusions. Sulfide inclusions, which are plastic at rolling temperatures and thus elongate and flatten during rolling, adversely affect ductility in the short transverse (through-thickness) direction. The chief role of rare-earth additive is to produce rare-earth sulfide and oxysulfide inclusions, which have negligible plasticity at even the highest rolling temperatures. Excessive amounts of cerium (>0.02%) and other rare-earth elements lead to oxide or oxysulfide stringers that may affect directionality. Treatment with rare-earth elements is seldom used because they produce relatively dirty steels. Treatment with calcium is preferred for sulfide and inclusion shape control.

As mentioned above, it is very well known that sulfide inclusions, which are

plastic at rolling temperatures, adversely affect ductility in the short transverse (through-thickness) direction and that in order to solve such problem, Ca, Mg, B and REM are added to produce their sulfide and oxysulfide inclusion, by using their chemical affinity to sulfur and oxygen, which have negligible plasticity at even the highest rolling temperature.

That is, the Okamoto reference only optionally adds well known hot workability improving elements such as Ca, Mg, B and REM, to its duplex stainless steel, in case that it is desired that its steel has further improved hot workability (refer to Col. 7, lines 46 – 50 in the Okamoto reference). In this regard, the Okamoto reference does not add any minimal hints and/or disclosures regarding the relationship between such an element including REM and intermetallic compound in the steel.

The Examiner also has again mistakenly alleged on page 7, lines 12-14 that Applicants have asserted the following statement: *"The duplex stainless steel of the present invention has good hot workability in itself due to a low S content and the nature of W, which does not serve to accelerate the formation of σ- and similar phase although added in a large amount".*

However, as argued in the paragraph bridging pages 8-9, and the following paragraph, in the Amendment dated January 22, 2008, **Applicants did not make the above noted statement**. As stated on page 10 of the Amendment dated July 13, 2007, the source of the quoted statement is column 7, lines 37-51 of the Okamoto reference. The above quoted statement is not Applicants' argument. This statement in

the Okamoto reference was referred to by Applicants (see pages 10-11 of the Amendment dated July 13, 2007). **<u>The Examiner is respectfully requested to acknowledge on the record that the source of the above noted quote is the Okamoto reference.</u>**

Regarding the further secondarily relied upon references, Applicants respectfully submit that these prior art references do not provide any minimal hints or disclosures regarding problems and solutions of the intermetallic or secondary phases and corrosion resistance of stainless steel.

As asserted in the Amendment dated July 13, 2007, it is well known that free-machining stainless steel can be made using inclusion such as Tellerium (Te) and Selenium (Se). SU 1148893 only discloses that Ba inclusion may show similar effects.

WO 01/57281 relates to a method for <u>grain refining</u> of steel, particularly ferritic and austenitic steels, i.e., duplex stainless steel, as the Examiner has mentioned, but it is not directed to a duplex steel itself but is directed to <u>a material or ferroalloy added to molten or liquid steel in the tapping ladle</u> in order to control the <u>solidification structure</u> as a small auxiliary agent, like FeMn (Ferromaganese) used as a deoxidizer for steel.

The Corwin reference is not directed to steel itself but is essentially directed to <u>dopants</u> which can be added to iron-base alloy material to dramatically improve their <u>resistance to oxidation</u>.

In the last paragraph on page 8 in the Response to Arguments section of the outstanding Office Action dated August 12, 2008, the Examiner has asserted that

Applicants have not provided factual evidence to substantiate that the claimed Ba, MM and/or Y contents are critical and possess unexpected results. Applicants respectfully disagree for the following reasons.

In the present application, several examples are presented in the specification and drawings showing that the present duplex stainless steel has an excellent corrosion resistance, embrittlement resistance, castability and hot workability, due to much suppressed formation of intermetallic phases.

Firstly, as all the corrosion tests such as the anodic polarization test, the critical pitting temperature (CPT) test and the critical crevice corrosion temperature (CCCT) test follow the condition specified by the ASTM (American Society for Testing and Materials) (refer to page 21, lines 4 – 8 of the present application), it is very easy to compare the present duplex stainless steel with the conventional (commercial) steels.

In Example 2 as described beginning on page 21 of the present application, Figs. 1A to 1F are pictures of microstructures showing precipitation of brittle intermetallic phases after aging heat-treated at 850°C for 30 minutes, and shows that the invention steels 4 (PREW* = 46.4), 10 (PREW* = 45.56) and 36 (PREW* = 47.34) have suppressed precipitation of the intermetallic phases more than commercial PREW 46-level duplex stainless steels UR 52+ (PREW* = 41.7) and SAF 2507 (PREW* = 41.86), to improve embrittlement resistance. That is, it is possible to increase PREW* compared to the commercial steels without producing the intermetallic phases. Example 3 also shows similar results.

Example 5 as described beginning at the bottom of page 22 of the present application, shows anodic polarization test (pitting resistance) results of invention steels in a cast state, compared to comparative steel in a cast state (refer to Fig. 4 and Example 5). Example 6 shows results of CCT and CCCT values of solution heat-treated steels, Example 7 shows results of anodic polarization test of solution heat-treated steels, and Example 8 shows results of anodic polarization test of aging heat-treated steels, in which the invention steels has shown higher pitting resistance than commercial high-grade duplex stainless steel UR 52N+, SAF 2507 and ZERON 100 and higher corrosion resistance than commercial high grade austenitic stainless steels AL-6XN, SR-50A and 254 SMO. Generally speaking, the austenitic stainless steel has superior corrosion resistance to the duplex stainless steel, but the austenitic stainless steel necessarily contains much more amounts of Ni, which is a very expensive alloying element, and thus is very expensive compared to the duplex stainless steel. Despite this, the invention steel shows superior corrosion resistance to the austenitic stainless steels as well as to the commercial duplex stainless steels.

The more detailed examples have been presented in Table 2, which shows that the invention steels had much higher CPT and CCCT than comparative and commercial steels (refer to Figs. 5, 6A, 6B, 7A and 7B, Table 2 and Examples 6, 7 and 8).

With regard to pitting resistances of the present invention as compared with those in the Okamoto reference, in the Okamoto reference the highest PREW* value is

47.1 at steel No. 7 in Table 2 of the Okamoto reference. In contrast, in accordance with the present invention, several examples are realized such as 9, 12, 13, 20, 22, 23, 26, 28, 29, 30, 31, 32, 34, 35, 36, 38, 39, 40 and 42, of which the PREW* values are above 47.1, as shown in the enclosed Table.

That is, in accordance with the present invention, PREW* value is increased without a danger of producing intermetallic phases, and thus superior pitting resistance to the Okamoto reference is realized as follows.

Even though the Okamoto reference shows pitting potential results (mV vs SCE) measured in an aqueous 20% NaCl solution at 80°C in Table 2 (refer to Col. 8, lines 54 – 60; Table 2 of the Okamoto reference) and the present invention shows pitting potentional results (mV vs SCE) measured in a much severe environment of 0.5N HCl + 1.0N NaCl solution at 50 and 70°C in Table 2 (refer to page 21, lines 4 – 8; Table 2 of present application), the steels according to the present invention show superior pitting potential to those of the Okamoto reference, because the meaning of "2)" in Table 2 indicates "Above equilibrium oxygen evolution potential: No pitting generated", which is above 858 mV vs SCE. In the Okamoto reference, only one specimen (steel No. 7) is similar with respect to pitting potential (850 mV vs SCE) to those of present invention. That is, in the present invention, due to the additionally added Ba (Claim 1) and MM and/or Y (Claim 4), which can actively suppress the intermetallic phases, the PREW* values or contents of Cr, Mo and W can be increased without a danger of the formation of intermetallic phases such as sigma and khi.

Accordingly, Applicants respectfully submit that the high-grade duplex stainless steel of claim 1 would not have been obvious in view of the prior art as relied upon by the Examiner taken singularly or together, and that this rejection of claims 1-3 and 5-17 is improper for at least the above reasons, in addition to the reasons as set forth in the Amendment dated January 22, 2008.

Claims 4-17 have been rejected in view of the Okamoto reference.

Applicants respectfully submit that the high-grade duplex stainless steel of claim 4 would not have been obvious in view of the Okamoto reference as relied upon by the Examiner, and that this rejection of claims 4-17 is improper, at least for the reasons as specifically set forth above with respect to the Okamoto reference, in addition to the reasons as set forth in the Amendment dated January 22, 2008.

Conclusion

The Examiner is respectfully requested to reconsider and withdraw the corresponding rejection, and to pass the claims of the present application to issue, for at least the above reasons.

In the event that there are any outstanding matters remaining in the present application, please contact Andrew J. Telesz, Jr. (Reg. No. 33,581) at (571) 283-0720 in the Washington, D.C. area, to discuss these matters.

Pursuant to the provisions of 37 C.F.R. 1.17 and 1.136(a), the Applicants hereby petition for an extension of three (3) months to February 12, 2009, for the period in

which to file a response to the outstanding Office Action. The required fee of $555.00 should be charged to Deposit Account No. 50-0238.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment for any additional fees that may be required, or credit any overpayment, to Deposit Account No. 50-0238.

Respectfully submitted,

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Enclosure: Comparative Table

Comparative Table

Alloys	N	PREW	PREW*
1	0.43	52.5	46.48
2	0.34	50.7	45.94
3	0.27	47.4	43.62
4	0.4	52	46.4
5	0.34	51.4	46.64
6	0.36	58.2	53.16
7	0.33	50.7	46.08
8	0.35	50.8	45.9
9	0.34	51.8	47.04
10	0.36	50.6	45.56
11	0.36	51.5	46.46
12	0.44	55.4	49.24
13	0.41	52.8	47.06
14	0.35	51	46.1
15	0.35	50.7	45.8
16	0.36	49.9	44.86
17	0.36	52	46.96
18	0.4	51.9	46.3
19	0.32	49.6	45.12
20	0.5	65.7	58.7
21	0.34	50.8	46.04
22	0.22	56.1	53.02
23	0.3	51.4	47.2
24	0.35	51.9	47
25	0.36	51.9	46.86
26	0.39	53.9	48.44
27	0.26	45.4	41.76
28	0.25	53.4	49.9
29	0.26	52.1	48.46
30	0.26	51.9	48.26
31	0.24	53.3	49.94
32	0.23	52.7	49.48
33	0.25	48.8	45.3
34	0.25	52.7	49.2
35	0.35	53.8	48.9
36	0.34	52.1	47.34
37	0.37	51.1	45.92
38	0.36	52.8	47.76
39	0.4	53.4	47.8
40	0.5	66.7	59.7
41	0.25	49.3	45.8
42	0.37	54.3	49.12
43	0.27	46	42.22
44	0.49	58	51.14
45	0.45	54.4	48.1
46	0.34	59.2	54.44
47	0.4	53.5	47.9
48	0.35	50.1	45.2
49	0.45	55.1	48.8
50	0.35	51.6	46.7
UR 52N+	0.25	45.2	41.7
SAF 2507	0.26	45.5	41.86
ZERON 100	0.26	46.7	43.06
SAF 2205	0.18	38.3	35.78
AL-6XN	0.21	48.3	45.36
SR-50A	0.25	51.5	48
254SMO	0.21	47.2	44.26
AISI 316L	-	25.5	25.5